Plant Sociology 58(2) 2021, 49–63 | DOI 10.3897/pls2021582/05

PENSOFT

Società Italiana di Scienza della Vegetazione (SISV)

Relevant habitats neglected by the Directive 92/43 EEC: the contribution of Vegetation Science for their reappraisal in Sicily

Riccardo Guarino[1], Salvatore Pasta[2], Giuseppe Bazan[1], Alessandro Crisafulli[3], Orazio Caldarella[4], Gian Pietro Giusso Del Galdo[5], Alessandro Silvestre Gristina[2], Vincenzo Ilardi[1], Antonino La Mantia[6], Corrado Marcenò[7], Pietro Minissale[5], Saverio Sciandrello[5], Leonardo Scuderi[8], Giovanni Spampinato[9], Angelo Troia[1], Lorenzo Gianguzzi[10]

1 *Department of Biological, Chemical and Pharmaceutical Sciences and Technologies (STEBICEF), University of Palermo, Italy*
2 *Institute of Biosciences and BioResources (IBBR), Italian National Research Council (CNR), Unit of Palermo, Italy*
3 *Department of Chemical, Biological, Pharmaceutical and Environmental Sciences (CHIBIOFARAM), University of Messina, Italy*
4 *Via Maria SS. Mediatrice 38, Palermo, Italy*
5 *Department of Biological, Geological and Environmental Sciences (BIGEA), University of Catania, Italy*
6 *Via Giotto 64, Palermo, Italy*
7 *Department of Botany and Zoology, Faculty of Science, Masaryk University, Brno, Czech Republic*
8 *Via Andromaca 60, Trapani, Italy*
9 *Department of Agricultural Sciences, Mediterranean University of Reggio Calabria, Italy*
10 *Department of Agricultural, Food and Forest Sciences (SAAF), University of Palermo*

Corresponding author: Riccardo Guarino (riccardo.guarino@unipa.it)

Subject editor: Daniela Gigante ♦ **Received** 6 December 2021 ♦ **Accepted** 19 December 2021 ♦ **Published** 31 December 2021

Abstract

Field investigation carried out by the Sicilian botanists in the last 20 years enabled them to identify eight habitat types of high biogeographic and conservation interest, neglected by the Directive 92/43, which deserve *ad hoc* conservation measures. For each of these habitats, a syntaxonomic interpretation of the corresponding plant communities, their main ecological, physiognomic and syndynamic traits and a list of diagnostic species are provided. Their classification into the macrotypes listed in the Annex I of the Directive 92/43 and the respective correspondence in EUNIS habitat classification are proposed. The habitats here described integrate those already proposed by the Italian Botanical Society, with the hope of an adequate recognition at national at supranational level.

Keywords

Habitat Directive, Natura 2000, Nature conservation, Sicily

Introduction

The Natura 2000 sites form a pan-European network for the *in situ* protection of species and habitats, recognized as conservation targets "of Community Importance" on the basis of Directive 92/43 EEC, which represents the most important regulatory instrument for the conservation of natural and semi-natural ecosystems in Europe (Evans 2012).

Designed to support the long-term survival of Europe's most valuable species and habitats, Natura 2000 sites constitute an environmental network to be managed through initiatives that should also fulfil socio-cultural and economic requirements at the local scale, with the general aim at achieving the best balance between ecological integrity and requirements of people living and working nearby (Tsiafouli et al. 2013; Linnell et al. 2015).

Even if originating from a species-specific concept (Kirk et al. 2016), the term "habitat" is frequently used to designate an integral unit, supporting ecological functions and species assemblages (Morrison and Mathewson 2015). This happens both in the EUNIS habitat classifi-

Copyright *Riccardo Guarino et al.* This is an open access article distributed under the terms of the Creative Commons Attribution License (CC BY 4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

cation (Rodwell et al. 2018) and in the Directive 92/43 EEC. Vascular plant communities are crucial to define EU habitats, both because plants are the least vagile and most visible component of terrestrial ecosystems, and because the vegetation cover and classification are the criteria by which the habitats of the Directive 92/43 (henceforth: Habitat Directive) are identified, delimited and mapped.

The census of natural habitats from the same Directive has given new impetus to basic taxonomic, syndynamic and ecological research, involving different disciplines (Blondet et al. 2017). Among these, vegetation science offered a significant contribution, considering that the units codified in the Annex I of the Habitat Directive often refer to the species composition and the structure of plant communities and sometimes explicitly refer to phytosociological units (Loidi et al. 2007; Tomaselli et al. 2016; Angelini et al. 2018; Attorre et al. 2018).

The explicit mention of some syntaxa by the Habitat Directive is important, also because this implicitly recognizes one fundamental postulate of phytosociology, that is: each phytocoenosis corresponds to a specific range of variability of environmental factors. Phytosociological studies carried out across the entire Sicilian territory during the last three decades pointed out the biogeographical importance of several habitats that deserve to be included in the Annex I of the same Directive. This paper aims to introduce these habitats and to discuss about the urgent need for their adequate recognition.

Material and Methods

Study area

The Sicilian Natura 2000 network counts on 245 protected sites, unevenly distributed throughout the island (Fig. 1). Among the Italian regions, Sicily is the one hosting the largest surface area of Special Areas of Conservation (SAC, based on the Habitat Directive), and Special Protection Areas (SPA, based on the Directive 79/409). These protected areas cover approximately a surface of 4710 km^2, corresponding to 18.3% of the Sicilian territory, sea excluded (www.mite.gov.it). Altogether, Sicily hosts 71 habitats listed in the Directive 92/43, of which 18 have priority conservation status. Additionally, 46 species from Annex II of the same Directive and 92 birds from the Directive 79/409 are recorded in Sicily.

The main feature of Sicily is a great geomorphologic and bioclimatic diversity, which originate ecological gradients of different intensity, also influenced by the distance from the sea and by the orientation and elevation of mountain ranges. In general, the natural patchiness of the Sicilian landscapes has been increased up to critical levels by human activities (Gianguzzi et al. 2016; Guarino and Pasta 2017).

Land use and human demography have significantly changed during the last seven decades, as a consequence

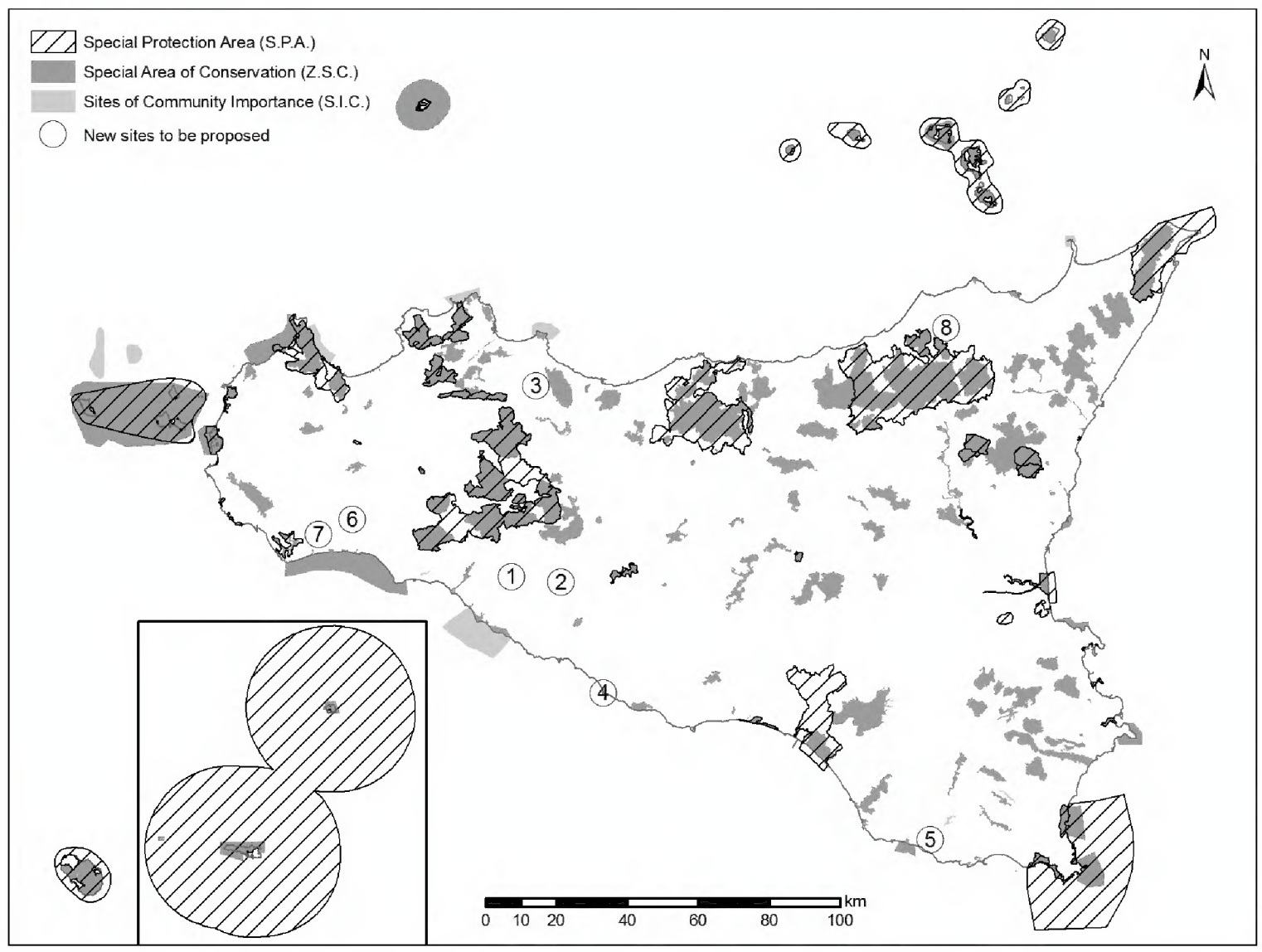

Figure 1. Natura 2000 sites in Sicily. Numbers indicate recently proposed new sites not yet approved by the Sicilian Regional Administration: 1. Maccalube e calanchi di Bissana, 2. Vallone di Ponte S. Biagio e calanchi di San Biagio; 3. Bosco e margi di Tumminia; 4. Punta Bianca; 5. Coste del Torrente Modica; 6. Castello della Pietra; 7. Parche di Bilello; 8. Versanti boscati umidi della Fiumara Tortorici.

of the mechanization of agriculture, the decline of extensive land use and traditional agriculture. Emblematic, in this case, is the almost complete abandonment of terraced fields (Barbera et al. 2009). The development of new economic sectors, like tourist services and infrastructure, promoted the concentration of people within a few miles from the coastline, with an ever-increasing impact on coastal habitats (Guarino and Guglielmo 2010). On the other hand, many lands which were used by agriculture or husbandry until recent times are currently abandoned, particularly in the mountain districts. For these reasons, two main kinds of Sites of Community Importance can be found in Sicily: those occurring on mountains are on average quite large; the coastal ones, instead, are on average rather small and set up in the attempt to save the savable, i.e. the few coastal stretches escaped from the massive urbanization which took place in recent decades as a consequence of the human migration coastwards (Mikhaylov et al. 2018). Indeed, the conservation and management of the Sicilian coastal sites, exposed to the pressure of strong economic interests, is quite problematic and poses several specific issues (Pasta et al. 2017; Guarino et al. 2021; Sciandrello et al. 2021).

Survey approach

The vegetation survey aimed at identifying the Sicilian habitats neglected by the Directive 92/43 was based both on phytosociological literature and on-site investigations conducted according to the Braun-Blanquet phytosociological approach (Braun-Blanquet 1964; Westhoff and van der Maarel 1978). The habitat description, syntaxonomic classification and designation of diagnostic species was carried out based on expert knowledge, supported by literature data and by the Expert System for the European EUNIS habitats (Chytrý et al. 2020).

The identification and nomenclature of vascular plants was based on Pignatti et al. (2017–2019), whereas the animal species names mentioned throughout the text follow Ruffo and Stoch (2005). The syntaxonomic nomenclature follows Mucina et al. (2016) and subsequent updates for Sicily (Guarino et al. 2017). The bioclimatic units refer to Bazan et al. (2015).

Results

Among the relevant habitats neglected by the Directive 92/43 EEC, which deserve greater attention to ensure their conservation in Sicily, it is worth mentioning:

a) relict communities dominated by plants at the edge of a wider distribution range, such as: the birch woods of *Betula pendula* subsp. *etnensis* (*Cephalanthero longifoliae-Betuletum etnensis*), restricted to the supramediterranean vegetation belt of Mount Etna (Brullo et al. 2012); the forest nuclei dominated by *Celtis tournefortii* subsp. *aetnensis* (*Pistacio terebinthi-Celtidetum aetnensis*), restricted to Sicani Mts., Nebrodi Mts. and Mount Etna (Gianguzzi et al. 2014b) or by *Ostrya carpinifolia*, scattered on the main mountain ranges of the island (Brullo et al. 2012); the broomfields with *Cytisus scoparius*, T*eline monspessulana* and *Adenocarpus* spp. occurring under cool and humid climatic conditions on the acidic soils of Etna, Nebrodi and Peloritani Mts.; the vegetation of dripping and shady rocky faces with Woodwardia radicans, occurring in few gorges of the Peloritani Mountains (Crisafulli 2007).
b) some outstanding habitats barely taken into account by the Directive and not adequately protected by national and regional laws, linked to localized and peculiar geomorphological units and hosting several vegetation units. This is the case of the annual swards and perennial grasslands, the sedge communities and the brackish temporary ponds co-occurring near the mud volcanoes and badlands of Macalube di Aragona, Terrapilata, Vulcanelli di Adrano, etc. (Pasta 2001; Brullo et al. 2010, 2013); the vegetation of the gypsum outcrops of southern and inner Sicily (Guarino and Pasta 2017; Musarella et al. 2018).
c) traditional landscapes shaped by century-long agro-forestry practices, such as the dehesa-like communities dominated by *Ceratonia siliqua* on the Hyblaean Plateau (SE-Sicily). This would reinforce the unit 63 of the Directive, i.e., sclerophyllous grazed forests (dehesas), currently recognizing only the habitat 6310 ("Dehesas with evergreen *Quercus* spp.").

The eight habitats described here integrate those already identified and proposed as additions to the Habitat Directive by the Italian Botanical Society (Table 1; Genovesi et al. 2014). Each of the newly proposed habitats is commented more in detail in the forms reported below.

1) Sicilian gypsum outcrops

Motivation: The plant communities growing on gypsum are a clear example of the strict relationship between substrate and vegetation, as many plant species grow exclusively or preferentially on such peculiar substrates (Escudero et al. 2015, Musarella et al. 2018). Gypsum habitats have historically been perceived as sterile, degraded areas with no special conservation interest that needed to be afforested or that could be used as dumping sites for urban waste (Escudero et al. 2015). Nowadays, they are acknowledged as habitats worth preserving due to their high number of endemic or exclusive plants (Escudero et al. 2015). However, these same communities represent often a largely underrated or ignored habitat, with serious consequences for both flora and fauna conservation (Musarella et al. 2018).

As already highlighted in Musarella et al. (2018), for the vascular flora, and Puglisi et al. (2020) for bryophytes, the Italian gypsum habitats could be included in the Habitat 1520* (Iberian gypsum steppes) extending its current definition in the Manual of Habitat interpretation, also

Table 1. Synoptic table resuming all the new habitat proposals from Sicily, their macrotype according to the Habitat Directive and the corresponding habitats in the EUNIS habitat classification.

MACROTYPE - Habitat Directive		New proposed Habitat	EUNIS habitat classification			Proposed by Genovesi et al. 2014	Proposed *hoc loco*
code	*Definition*		*EUNIS 2021 code*	*Red List code*	*EUNIS-2020 habitat name*		
15	Salt and gypsum inland steppes	Sicilian gypsum outcrops	S65	F6.7	Mediterranean gypsum scrub		•
15	Salt and gypsum inland steppes	Mud volcanoes and badlands in the evaporitic outcrops of Sicily	S66 R61	F6.8a E6.1	Mediterranean halo-nitrophilous scrub Mediterranean inland salt steppe		•
31	Standing water	Fresh water sedge- and reedbeds	Q51 Q53	C5.1a C5.2	Tall-helophyte bed Tall-sedge bed	•	
32	Running water	Montane brooks of southern Apennines and Sicily	C21a	C2.1a	Base-poor spring and spring brook	•	
51	Sub-Mediterranean and temperate scrub	Meso- and supramediterranean acidophilous Sicilian broomfields	S33	F3.1c	Lowland to montane temperate and submediterranean genistoid scrub		•
63	Sclerophyllous grazed forests	Small woods dominated by *Celtis tournefortii* subsp. *aetnensis*	S51	F5.1	Mediterranean maquis and arborescent matorral		•
63	Sclerophyllous grazed forests	"Chiuse" with *Ceratonia siliqua* of south-eastern Sicily	T24	G2.4	*Olea europaea-Ceratonia siliqua* forest		•
63	Sclerophyllous grazed forests	Centuries-old olive groves with evergreen oaks and arborescent matorral	T24	G2.4	*Olea europaea-Ceratonia siliqua* forest	•	
72	Other rocky habitats	Shady dripping cliffs with *Woodwardia radicans* and other large ferns	U3D	H3.4	Wet inland cliff		•
72	Other rocky habitats	Mediterranean dripping cliffs	U3D	H3.4	Wet inland cliff	•	
72	Other rocky habitats	Water springs with moss-rich vegetation on siliceous or carbonatic substrates	C21b C21a	C2.1a C2.1b	Base-poor spring and spring brook Calcareous spring and spring brook	•	
92	Mediterranean deciduous forests	Birch woodlands of Mount Etna	T1D	G1.9b	Southern European mountain *Betula* and *Populus tremula* forest on mineral soils		•
92	Mediterranean deciduous forests	*Ostrya carpinifolia* woods of Sicily	T1A	G1.7b	Mediterranean thermophilous deciduous forest		•

with the addition of the Italian vascular and moss gypsophytes. Similarly, the habitat has been recently recognized in Cyprus (Manolaki Vogiatzakis 2017), at the opposite side of the Mediterranean Basin, and it stretches northwards up to the submediterranean gypsum outcrops of the Northern Apennine.

Macrotype: 15 Salt and gypsum inland steppes

Name: Sicilian gypsum outcrops.

Description: Garrigues, perennial grasslands and annual swards colonizing gypsum-rich shallow soils and gypsum outcrops in the southern and central part of Sicily, under thermo- and mesomediterraean climatic conditions. These plant assemblages include several gypsophilous species, mainly belonging to the families *Lamiaceae* (genera *Micromeria*, *Teucrium*, *Thymus*, *Thymbra*), *Cistaceae* (*Fumana*, *Helianthemum*), *Asteraceae* (*Centaurea*, *Jurinea*, *Santolina*, *Frankenia*) and *Brassicaceae* (*Alyssum*, *Erysimum*, *Matthiola*). All of them are adapted to several environmental stresses, such as: long-lasting seasonal drought, base-rich substrates (especially in the most eroded sites and on lithosols), high solar radiation, exacerbated by the high reflectance of rock outcrops.

Diagnostic sentence: Garrigues, grasslands and annual swards colonizing gypsum-rich substrates of the hilly areas of inner and southern Sicily.

List of diagnostic species: In addition to the species already listed as gypsum-specialists by Musarella et al. (2018) and Puglisi et al. (2020): *Chaenorhinum rupestre*, *Festuca gypsophila*, *Sedum gypsicola* subsp. *trinacriae*, *Petrosedum ochroleucum* subsp. *mediterraneum*, many other species prefer gypsum-rich substrates in Sicily, although not being exclusive of this substrate type. This is the case of: *Astragalus caprinus* subsp. *huetii*, *Brassica villosa* subsp. *tinei*, *Diplotaxis crassifolia*, *Echinaria capitata* var. *todaroana*, *Erysimum metlesicsii*, *Gypsophila arrostii* subsp. *arrostii*, *Scabiosa parviflora*.

Dynamic contacts: Although gypsum outcrops have for long time been interpreted as the result of the extreme degradation and erosion of previously forested areas, this is probably true only for gently sloping or almost flat areas. Indeed, some small and scattered evergreen (*Quercus ilex*) or semideciduous (*Quercus pubescens*) oak forest fragments still occur nowadays on the deeper gypsum-rich soils of central and southern Sicily (Bazan et al. 2006; Brullo et al. 2009).

As for the steps of progressive vegetation dynamics on gypsum-rich soils, in the absence of disturbance almost bare rock outcrops only hosting moss- and lichen-rich communities are gradually covered with annual gypsophilous sward (*Sedo-Ctenopsion gypsophilae*). If pedogenesis is not hindered by frequent disturbances, new therophytic assemblages (referred to *Stipion retortae* or *Plantagini-Catapodion balearici*) can develop and evolve towards perennial grasslands (*Hyparrhenion hirtae* under thermomediterranean bioclimatic conditions, *Avenulo-Ampelodesmion* under meso-mediterranean, *Charybdido-Asphodelion* under high grazing pressure). The most mature communities currently found on gypsum-rich substrates are garrigues, framed into the alliance *Cisto-Ericion multiflorae*.

Phytosociological arrangement: *Brassico tinei-Diplotaxietum crassifoliae* Brullo Marcenò 1979 [*Dianthion rupicolae* Brullo Marcenò 1979, *Asplenietalia glandulosi* Br.-Bl. in Meier Br.-Bl. 1934, *Asplenietea trichomanis* (Br.-Bl. in Meier Br.-Bl. 1934) Oberd. 1977]; *Phagnalo saxatilis-Cheilanthetum maderensis* Loisel 1970 corr. Pérez-Carro et al. 1989, aggr. with *Sedum gypsicola* subsp. *trinacriae* and *Petrosedum ochroleucum* subsp. *mediterraneum* [*Phagnalo saxatilis-Cheilanthion maderensis* Loisel 1970 corr. Pérez-Carro et al. 1989, *Cheilanthetalia maranto-maderensis* Sáenz de Rivas Rivas-Mart. 1979, *ibidem*]; *Rosmarino officinalis-Thymbretum capitatae* Furnari 1965 [*Cisto eriocephali-Ericion multiflorae* Biondi 2000, *Cisto-Micromerietalia julianae* Oberd. 1954, *Ononido-Rosmarinetea* Br.-Bl. in A. Bolòs y Vayreda 1950]; *Hyparrhenietum hirto-pubescentis* A. Bolòs y Vayreda O. de Bolòs Br.-Bl. in A. Bolòs y Vayreda 1950 [*Hyparrhenion hirtae* Br.-Bl., P. Silva Rozeira 1956, *Cymbopogono-Brachypodietalia ramosi* Horvatić 1963, *Lygeo sparti-Stipetea tenacissimae* Rivas-Mart. 1978]; *Astragalo huetii-Ampelodesmetum mauritanici* Minissale 1995 [*Avenulo-Ampelodesmion mauritanici* Minissale 1995, *ibidem*]; *Thapsio garganicae-Feruletum communis* Brullo 1984, *Ferulo communis-Hyparrhenietum hirtae* Brullo Siracusa 1996, *Carlino siculae-Feruletum communis* Gianguzzi, Ilardi Raimondo 1996, *Cachryo siculae-Brachypodietum retusi* Brullo, Giusso Scuderi 2010, aggr. with *Elaeoselinum asclepium* [*Charybdido pancratii-Asphodelion ramosi* Biondi et al. 2016, *Asphodeletalia ramosi* Biondi in Biondi et al. 2016, *ibidem*]; *Ononido breviflorae-Stipetum capensis* Brullo, Guarino Ronsisvalle 2000 [*Stipion retortae* O. de Bolòs 1957, *Brachypodietalia distachyi* Rivas-Mart. 1978, *Stipo-Trachynietea distachyae* Brullo in Brullo, Scelsi Spampinato 2001], *Filagini-Chaenorhinetum rupestris* Brullo, Marcenò, Minissale Spampinato 1989 corr. [*Sedo-Ctenopsion gypsophilae* Rivas Goday Rivas-Martínez ex Izco 1974, *Stipo-Bupleuretalia semicompositi* Brullo in Brullo, Scelsi Spampinato 2001, *ibidem*]; *Atractylido cancellatae-Neatostemetum apuli* Brullo, Scelsi Siracusa 1994 [*Plantagini-Catapodion balearici* Brullo 1985 nom. mut. propos., *ibidem*].

2) Mud volcanoes and badlands in the evaporitic outcrops of Sicily

Motivation: Already studied by early naturalists such as Pliny the Elder and eminent geologists like Deodat de Dolomieu and Charles Lyell, around 15 mud volcanoes occur in the inland areas of Sicily. Mud volcanoes alternate an almost continuous degassing activity and episodes with ejection of large quantities of mud. The protection of these absolute naturalistic highlights gave birth to many protected areas worldwide, namely in the SE-European and middle-central Asian countries bordering the Black and the Caspian Sea, in the Indian Ocean and in the Americas. In Italy, mud volcanoes also occur in Emilia-Romagna, Marche, Tuscany and Latium regions. Some of them are nature reserves, such as the "Salse di Nirano" in Emilia-Romagna, whilst many others are lacking any protection.

Like other poorly vegetated but geologically peculiar habitats (e.g. 8320: Fields of lava and natural excavations), the Sicilian mud volcanoes and badlands are worth being included in the 92/43 EEC Directive as a whole, not only for their naturalistic and aesthetic value, but also for their increasing vulnerability, exacerbated by absurd destinations (e.g., waste dumping grounds, go kart and motocross trails) and disturbances such as wildfires, overgrazing by domestic herbivores, unsustainable cereal crop cultivation practices, reforestation with alien trees, which currently compromise many of these unique, hostile habitats by accelerating the natural erosive processes affecting them.

Because many mud volcanoes and badlands are located in poorly investigated areas, their occurrence has often been overlooked and, consequently, they have not been included in the Sicilian Natura 2000 network. Indeed, some Sicilian endemics, like *Tripolium sorrentinoi* (= *Aster sorrentinii*), *Limonium calcarae*, *Allium agrigentinum*, *Malva agrigentina* only grow on badlands or close to mud volcanoes. Of these species, Tripolium sorrentinoi is the only one mentioned in the Annex II of the 92/43 EU Directive. All these plant species, classified as critically endangered or vulnerable according to IUCN criteria, are currently experiencing a rapid shrinkage, and some have already gone extinct, as in the case of *Puccinellia gussonei*. Hence, the inclusion of Sicilian badlands in the 92/43 EEC Directive is urgently required also for plant conservation purposes.

Macrotype: 15 Salt and gypsum inland steppes

Name: Mud volcanoes and badlands in the evaporitic outcrops of Sicily

Description: Mud volcanoes with almost continuous degassing activity and patchy halo-tolerant xerophitic vegetation colonizing the top, the slopes and the base of the steep to gently sloping and rounded badlands. Such vegetation occurs on marly, clayey-marly and salty-clayey substrates of the geological unit "Formazione Gesso-Solfifera", including several sedimentary materials accumulated during the Messinian Salinity Crisis. This habitat is mostly concentrated in the inner part of Sicily and hosts both xerophilous and hygrophilous grassland communities, adapted to face different severe and counteracting stress factors (e.g., winter soil waterlogging and oxygen shortage, summer water shortage and cracking). Sicilian mud volcanoes occur in the Province of Agrigento, Caltanissetta and Catania (Cangemi Madonia, 2014). Some of these went destroyed during the last century, including the ones forming the famous lake Naphtia, near Palagonia, home of the divine twins Palikoi, feared and venerated by central-eastern Sicilians already three thousand years ago. Clayey and marly badlands are more widespread throughout the island, particularly in the provinces of Agrigento, Caltanissetta, Enna and Catania,

with minor spots in the provinces of Trapani and Palermo (Brullo et al. 2010, 2013; Pasta Guarino 2017).

Diagnostic sentence: Thermo- to mesomediterranean sparsely vegetated clayey and marly evaporitic outcrops, badlands and mud volcanoes of Sicily (local names: salinelle, calanchi, vulcanelli, macalube, caldare).

List of diagnostic species: *Lygeum spartum*, *Caroxylon agrigentinum*, *Tripolium sorrentinoi*, *Limonium calcarae*, *Limonium optimae*, *Limonium opulentum*, *Malva agrigentina*, *Allium agrigentinum* (incl. *A. castellanense*), *Scabiosa parviflora*, *Moricandia arvensis*, *Eruca longirostris*, *Cardopatium corymbosum*, *Tyrimnus leucographus*, *Scorzoneroides muelleri* subsp. *muelleri*, *Sphenopus divaricatus*, *Trifolium congestum*, *Anthemis muricata*, *Astragalus raphaelis*, *Senecio leucanthemifolius* subsp. *pectinatus*.

Dynamic contacts: Mud volcanoes are bare areas, totally devoid of vascular plant cover, but they may host interesting algal communities. The halo-nitrophilous scrub communities of the harshest badlands (*Salsolo oppositifoliae-Suaedion fruticosae*, *Pegano harmale-Salsoletea vermiculatae*) are dominated by few species adapted to face the hyperarid conditions and the intense erosion of the steep slopes. Some sub-nitrophilous plant communities referred to *Artemision arborescentis* may occur on more humid badlands under meso-mediterranean bioclimatic conditions. The drought stress-tolerant communities, framed into *Moricandio-Lygeion sparti* (*Lygeo sparti-Stipetea tenacissimae*), are dominated by few hemicryptophytes and are rich in narrow endemics. On clayey or loamy compact soils, *Lygeum*-dominated grasslands are often intermingled with halo-subnitrophilous sparse ephemeral swards framed into *Frankenion pulverulentae* (*Saginetea maritimae*), also colonising the gently sloping margins of temporary ponds, while the bare ridges and the steepest eroded slopes are characterised by the uneven cover of therophytic assemblages referred to *Gaudinio fragilis-Podospermion cani*. Badlands and mud volcanoes may form complex landscapes hosting a patchwork of hygrophilous communities referred to *Charetea fragilis*, *Isoeto-Nanojuncetea*, *Juncetea maritimi*, *Phragmito-Magnocaricetea* and *Nerio-Tamaricetea*.

Phytosociological arrangement: *Limonio opulenti-Salsoletum oppositifoliae* Brullo, Grillo Scalia 1980, *Limonio catanzaroi-Salsoletum oppositifoliae* Brullo, Guglielmo Pavone 1986, *Salsoletum agrigentinae* Brullo, Guglielmo Pavone 1986, *Capparido siculae-Salsoletum oppositifoliae* Brullo et al. 2012, *Limonio calcarae-Suaedetum verae* Brullo et al. 2012 [*Salsolo oppositifoliae-Suaedion fruticosae* Rigual 1972, *Salsolo vermiculatae-Peganetalia harmalae* Br.-Bl. O. de Bolòs 1954, *Pegano harmalae-Salsoletea vermiculatae* Br.-Bl. O. de Bolòs 1958]; *Atriplici halimi-Artemisietum arborescentis* Biondi 1988, *Limonio optimae-Salsoletum oppositifoliae* Brullo et al. 2012, *Lycio intricati-Salsoletum oppositifoliae* Brullo et al. 2012 [*Artemision arborescentis* Géhu Biondi in Géhu et al. 1986, ibidem]; *Eryngio dichotomi-Lygeetum sparti* Gentile Di Benedetto 1961 corr. C. Brullo et al. 2010, *Tripolietum sorrentinoi* Venturella, Ottonello Raimondo 1984 nom. mut. propos., *Lavatero agrigentinae-Lygeetum sparti* Brullo 1985 corr. C. Brullo et al. 2010, *Phagnalo annotici-Lygeetum sparti* Biondi Mossa 1993 [*Moricandio-Lygeion sparti* Brullo, De Marco Signorello 1990, *Lygeo-Stipetalia tenacissimae* Br.-Bl. O. de Bolòs 1958, *Lygeo sparti-Stipetea tenacissimae* Rivas-Mart. 1978]; *Hordeo maritimi-Spergularietum salinae* Sciandrello 2005, *Sphenopo divaricati-Spergularietum maritimae* Sciandrello 2007, *Polypogonetum subspathacei* Gamisans 1992 [*Frankenion pulverulentae* Rivas-Mart. ex Castroviejo Porta 1976 (incl. *Polypogonion subspathacei* Gamisans 1992), *Frankenietalia pulverulentae* Rivas-Mart. ex Castroviejo Porta 1976, *Saginetea maritimae* Westhoff, van Leeuwen Adriani 1962]; *Podospermo cani-Parapholidetum pycnanthae* Brullo Siracusa 2000, *Chamaemelo fuscati-Leontodontetum muelleri* Brullo Siracusa 2000, *Sphenopo divaricati-Spergularietum diandrae* Brullo Siracusa 2000 [*Gaudinio fragilis-Podospermion cani* Brullo Siracusa 2000, *ibidem*].

3) Meso- and supramediterranean acidophilous Sicilian broomfields

Motivation: The meso- and supramediterranean acidophilous Sicilian broomfields represent the most south-eastern and isolated stands of pertaining to a group of plant communities with Iberian-Atlantic distribution. The chief species of this vegetation type spread in Sicily during the hypsothermal period following the last glacial event (during the Atlantic and Subboreal chronozones, see Orombelli Ravazzi, 2002) and have persisted in local areas where the summer aridity is buffered by orographic moisture condensation and water-rich acidic soils. This vegetation type migrated through southern France and along the Tyrrhenian side of the Apennines and Calabrian Massifs, until reaching north-western Sicily (De Beaulieu et al. 2005). Here, the isolated populations in some cases gave rise to new, autonomous lineages as a consequence of the geographic isolation and the adaptation to mountain ecosystems (Sciandrello et al. 2015). Owing to the biogeographical interest and the occurrence of exclusive endemic species, this habitat deserves adequate protection.

Macrotype: 51 Sub-Mediterranean and temperate scrub

Name: Meso- and supramediterranean acidophilous Sicilian broomfields

Description: Mesophilous forest fringes and shrublands dominated by *Pteridium aquilinum* and genistoid nanophanerophytes with flexible and elongated green branches, growing on humid, non-eroded, nutrient-poor acidic soils. The dominant species, thanks to the symbiosis with nitrogen-fixing bacteria, play an important role in soil-formation processes. Such vegetation s widespread in the western territories of the Mediterranean, sub-Atlantic and Atlantic regions, often as seral stages replacing oak-dominated mixed deciduous woods. In Sicily, it is rather common along the Peloritani and Nebrodi moun-

tains and on Mount Etna, on soils deriving from quartz sandstones, metamorphic siliceous rocks and volcanic debris, within the meso- and supramediterranean subhumid to hyperhumid bioclimatic belts (Bartolo et al. 1994; Guarino 1998; Siracusa 1997; Gianguzzi 1999). The vegetation included in this habitat thrives particularly well on sea-facing submontane and mountain slopes, where it benefits from the condensation of moist air currents rising from the sea.

Diagnostic sentence: Mesophilous forest fringes and shrublands dominated by *Pteridium aquilinum* and genistoid nanophanerophytes, growing on nutrient-poor acidic soils, within the meso- and supra-Mediterranean, subhumid to hyperhumid bioclimatic belt.

List of diagnostic species: *Cytisus infestus*, *Cytisus scoparius*, *Cytisus villosus*, *Erica arborea*, *Genista etnensis*, *Orobanche rapum-genistae*, *Pteridium aquilinum*, *Spartium junceum*, *Teline monspessulana*, *Thymus longicaulis*, *Tuberaria lignosa* and the following endemic Sicilian or Calabrian-Sicilian species: *Adenocarpus commutatus*, *Anthemis messanensis*, *Euphorbia corallioides*, *Fritillaria messanensis* and *Viola aethnensis*.

Dynamic contacts: Vegetation dynamically related to mesophilous woods (particularly *Erico-Quercetum virgilianae* and *Teucrio siculi-Quercetum ilicis*) and thickets of *Ericion arboreae*. On summit windy ridges it represents the primary vegetation, forming a patchwork with herb-dominated pasturelands ascribed to the *Plantaginion cupanii* (*Molinio-Arrhenatheretea*) and, if overgrazed, with transitional stages of *Pteridio-Tanacetetum siculi* (*Onopordetea acanthii*).

Phytosociological arrangement: *Cytiso infesti-Adenocarpetum commutati* Bartolo, Brullo Pulvirenti 1994 mut. Guarino Pasta 2017, *Pteridio aquilini-Euphorbietum corallioidis* Guarino 1998 nom. inval. [*Violo messanensis-Adenocarpion brutii* Mucina in Mucina et al. 2016 mut. Guarino Pasta 2017; *Cytisetalia scopario-striati* Rivas-Mart. 1974; *Cytisetea scopario-striati* Rivas-Mart. 1974]; *Cytiso infesti-Spartietum juncei* Guarino 1998 nom inval. [All. to be defined, *Cytiso villosi-Telinetalia monspessulanae* Rivas-Martínez, Galán Cantó in Rivas-Martínez, T.E. Díaz, Fernández-González, Izco, Loidi, Lousã Penas 2002, *ibidem*].

4) Small woods dominated by *Celtis tournefortii* subsp. *aetnensis*

Motivation: *Celtis tournefortii* is a widely distributed species ranging along the south-eastern border of continental Europe, from the southern slopes of Caucasus to the Balkan and Aegean regions (Browicz Zieliński 1984; Tutin 1991; Boratyński et al. 1992). The Sicilian populations of the species, referred to the subsp. aetnensis, represent the most western and isolated outpost of its distribution range, testifying Miocene connections between the Balkan and Tyrrhenian territories (Montelucci 1972; Tomaselli 1972; Pezzetta 2010). These Sicilian populations show a circumscribed and fragmentary distribution, occupying refuge habitats of remarkable phytogeographic interest, worthy to be preserved.

Macrotype: 63 Sclerophyllous grazed forests

Name: Small woods dominated by *Celtis tournefortii* subsp. *aetnensis*

Description: Small woods dominated by *Celtis tournefortii* subsp. *aetnensis*, 3-6 m tall, distributed in scattered patches of 200-400 square meters, from 380 m to 1340 m a.s.l., between the upper dry thermomediterranean and the sub-humid supramediterranean bioclimate. The stands occur on stony sites with different outcropping rocks, such as the lava flows (locally named "sciare") on the south-western slopes of Mount Etna, quartz sandstones (southern slopes of the Nebrodi Mts. and Madonie Mts., near Gangi), marly-limestone screes (Sicani Mountains and lower part of the southern slope of Rocca Busambra), up to the summit ridges of Rocca Busambra, on cryoturbated calcareous-dolomitic outcrops (Troia 1997; Schicchi Marino 2011; Gianguzzi et al. 2014).

Diagnostic sentence: Small woods dominated by *Celtis tournefortii* subsp. *aetnensis*, associated with *Pistacia terebinthus* and evergreen species and lianas of the Mediterranean scrub. These woods consist of relict, scattered patches settled in xeric and stony habitats, between the dry thermomediterranean and the sub-humid supramediterranean bioclimatic belts.

List of diagnostic species: *Celtis tournefortii* subsp. *aetnensis*, *Pistacia terebinthus*, *Olea europaea* var. *sylvestris*, *Asparagus albus*, *Clematis cirrhosa*, *Smilax aspera*, *Ruta chalepensis* (*Pistacio terebinthi-Celtidetum aetnensis -typicum*); *Rhamnus alaternus*, *Phillyrea latifolia* (*-rhamnetosum alaterni*); *Phlomis fruticosa* (*-phlomidetosum fruticosae*); *Artemisia arborescens* (*-artemisietosum arborescentis*).

Dynamic contacts: The vegetation at issue tends to have a primary character and plays an important ecological role in stabilizing screes and detrital fans, representing the most evolved aspect of the "Sicilian hilly and submontane, detrital, indifferent edaphic, thermo-mesomediterranean subhumid series of the *Pistacio terebinthi-Celtido aetnensis* sigmetum". This edaphophilous series is strongly affected by frequent rock falls and landslides and by local microclimatic conditions, with remarkably wide daily and annual temperature ranges. Towards the central part of the detrital fan, the *Pistacio terebinthi-Celtido aetnensis* sigmetum gets in catenal contact with the shrubby and herbaceous vegetation of the scree microgeoseries, while at the edge of the its habitat, the sigmetum can be in contact with woodlands dominated, either by: a) *Quercus ilex* (habitat 9340), linked to rocky habitats with deeper soil (e.g., *Aceri campestris-Quercetum ilicis* on the Sicani Mountains, as well as *Teucrio siculi-Quercetum ilicis* on Mount Etna); b) *Quercus pubescens* s.l. (habitat 91AA - Eastern white oak woods), on deeper and more evolved soils (e.g., *Oleo sylvestris-Quercetum virgilianae* on the Sicani Mountains and Rocca Busambra, as well as *Celtido aetnensis-Quercetum virgilianae* and *Festuco heterophyl-*

lae-Quercetum congestae on Mount Etna). In the upper part of its growing sites, the *Pistacio terebinthi-Celtido aetnensis* sigmetum can also be in contact with the vegetation of rocky cliffs (habitat 8210, calcareous rocky slopes with chasmophytic vegetation), or with the Mediterranean maquis ascribed to the habitat 5330 (*Euphorbia dendroides*-maquis), with the perennial and annual dry grasslands of the habitat 6220* (Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*) or with the thermoxeric sclerophillous woods ascribed to the habitat 9320 (*Olea* and *Ceratonia* forests).

Phytosociological arrangement: *Pistacio terebinthi-Celtidetum aetnensis* Gianguzzi, Cusimano Romano 2014 [*Oleo-Ceratonion* Br.Bl.1936 ex Guinochet Drouineau em. Rivas-Martínez 1975, *Pistacio-Rhamnetalia alaterni* Rivas-Martínez 1975, *Quercetea ilicis* Br.-Bl.1947 in Br.-Bl., Roussine Nègre 1952].

5) "Chiuse" with *Ceratonia siliqua* of south-eastern Sicily

Motivation: The so-called chiuse represent a cultural landscape of the south-eastern Sicily, characterised by an intricate network of dry limestone walls delimiting regular polygons where pastureland or thermo-Mediterranean garrigue are shaded by a very open canopy of carob trees (Bianca 1881; Ente Fauna Siciliana 2003; D'Amato 2018). Local agro-pastoral practices, mostly based on a biennial rotation system, maintain good levels of productivity with no need of chemicals for soil fertilization or against weeds and pathogens. Such extensive land use, combined with the lower impact of cattle grazing with respect to other domestic herbivores, is responsible for the high species richness recorded within chiuse (Baumel et al. 2018). Although chiuse host few preferential/differential plant species, they are home to many rare, protected, and endemic plants, like the orchids *Ophrys calliantha*, *Ophyrs discors* and *Ophrys lunulata*, the last being a priority species according to 92/43 EEC Directive. Chiuse also represent an important habitat for prey birds (e.g., *Buteo buteo*, *Falco tinnunculus*, *Tyto alba*), for the Sicilian Rock Partridge (*Alectoris graeca* subsp. *whitakeri*) and for several important migratory birds (e.g., *Alauda arvensis*, *Coturnix coturnix*).

Macrotype: 63 Sclerophyllous grazed forests

Name: "Chiuse" with *Ceratonia siliqua* of south-eastern Sicily

Description: The native status of the island's carob populations is still under debate (Ramón-Laca 2004; Viruel et al. 2020): in fact, ancient documents never mention forest communities dominated by carob trees, while many of them attest the extensive cultivation of this species since the XVII century after huge forest clearings (e.g., in the territory of Vittoria, once part of the Countee of Modica). The construction of these fenced areas is intimately related to the stony and rugged characteristics of the Hyblaean Plateau. Since ancient times, to enhance agro-pastoral activities local inhabitants used to create stone mounds along border of their properties. These mounds were gradually transformed into dry limestone walls to delimit crop fields, tree groves, or, more frequently, agro-silvo-pastoral complex ecosystems with crop fields and pastures and an uneven and scattered olive, almond, azerole and more frequently carob tree cover, with average low density of (often huge and aged) individuals (10-20 plants per hectare). This complex landscape and its cultural landmarks (stone walls, terraced groves, etc.) are generally well preserved; they were able to survive across the centuries and to face modernity because local rural economy, after experiencing some decades of economic crisis between 1970s and 2000s, re-started thanks to brilliant marketing initiatives (e.g., eco-tourism) valorising local agro-pastoral activities and products. For instance, the toasted flower obtained from carob pods is used to produce the famous "chocolate of Modica", while these pastures feed the free-roaming cows of a local breed called "modicana", producing the renowned "caciocavallo ragusano" cheese. Another traditional knowledge linked to carob trees is the local culinary use of Laetiporus sulphureus (whose vernacular name is "funcia ri carrùa"), a mushroom frequently associated with *Ceratonia siliqua*.

During last decades many chiuse located near the coast have been transformed into greenhouses for vegetable production and have been lost forever. Today the major threats to these man-made ecosystems are the abandonment of the land and traditional practices. Due to progressive succession processes, this agro-silvo-pastoral system is slowly changing into an intricate Mediterranean maquis. In addition, another threat for the "chiuse", also featured in the national catalogue of the rural historical landscapes (https://www.reterurale.it/flex/cm/pages/ServeBLOB.php/L/IT/IDPagina/14376), is the transformation of ancient farms to make new private estates with no respect for traditional building style and/or not using local stone material.

Diagnostic sentence: Extensive land-use typical of south-eastern Sicily, characterised by an intricate network of dry limestone walls delimiting regular polygons where pastureland or thermo-Mediterranean garrigue are shaded by a very open canopy of *Ceratonia siliqua*.

List of diagnostic species: *Amygdalus webbii*, *Asparagus acutifolius*, *Asparagus albus*, *Asparagus aphyllus*, *Ceratonia siliqua*, *Olea europaea*, *Phillyrea latifolia*, *Pistacia lentiscus*, *Prasium majus*, *Rubia peregrina*, *Smilax aspera* and *Teucrium fruticans*.

Dynamic contacts: Along the south-eastern coast of Sicily the chiuse with carob trees get in contact with the communities of the *Periplocion angustifoliae* and in particular with the association *Calicotomo infestae-Rhoetum tripartitae* or with the communities of the *Oleo-Ceratonion* (*Myrto communis-Pistacietum lentisci*). In these contexts, the grazed chiuse host a mosaic of communities framed into the *Echio-Galactition*, perennial grasslands referred to the *Hyparrhenietum hirto-pubescentis*, annual grasslands (*Plantagini coronopi-Catapodietum mari-*

ni, *Anthemido secundirameae-Allietum lehmanii* and, on rocky outcrops, *Thero-Sedetum caerulei*). In the inland, the chiuse are characterized by scattered remnant downy oak forest stands ascribed to *Oleo sylvestris-Quercetum virgilianae* and perennial grassland communities issuing from woodland degradation (*Avenulo-Ampelodesmion mauritanici*).

Phytosociological arrangement: *Oleo-Ceratonion siliquae* Br.-Bl. 1936 ex Guinochet Drouineau 1944 em. Rivas-Mart. 1975 [*Pistacio lentisci-Rhamnetalia alaterni* Rivas-Mart. 1975, *Quercetea ilicis* Br.-Bl. ex A. Bolòs y Vayreda O. de Bolòs in A. Bolòs y Vayreda 1950].

6) Shady dripping cliffs with *Woodwardia radicans* and other large ferns

Motivation: The Mediterranean dripping cliffs are sometimes characterized by bryo-pteridophytic sciaphilous-hygrophilous communities hosting rare and endangered ferns of remarkable phytogeographic interest, such as *Woodwardia radicans*, *Osmunda regalis*, *Pteris vittata*, *Pteris cretica*, *Asplenium scolopendrium*, many of them included in Italian Red List or Atlases of threatened species (Conti et al. 1992, 1997; Scoppola Spampinato 2005; Rossi et al. 2013).

Woodwardia radicans is a conservation target included in Annex II of Directive EEC 43/92 and in the IUCN Red List with the status of "Endangered" for the Mediterranean basin (De Belair 2010) and "Vulnerable" for Europe (Christenhusz et al. 2017). In Sicily, according to IUCN criteria it is considered an "Endangered" species (Spampinato et al. 2008), a status recently confirmed (Crisafulli et al. 2021).

The need for a specific habitat type concerning shady dripping cliffs had already been highlighted by Spampinato Puglisi (2009) in the drafting of the Italian Manual for the Interpretation of habitats under 92/43 EEC Directive. Up to now the bryo-pteridophytic communities of the class *Adiantetea* are not recognized as a habitat of Community interest, although they are important for the conservation of various hygrophilous and rupicolous species.

Due to climate change and the diversion of water flows for agricultural or urban purposes, the extent of this habitat is continuously decreasing in Sicily: for instance, it has disappeared on Mount Etna since a century and is now found exclusively in a few localities in the Peloritani Mountains (Crisafulli et al. 2021).

Macrotype: 83 Other rocky habitats

Name: Shady dripping cliffs with *Woodwardia radicans* and other large ferns

Description: Dense, three-layered vegetation consisting of a dense moss carpet, thickly covered by the fronds of *Adiantum capillus-veneris*, in turn loosely covered by the fronds of large ferns, such as *Woodwardia radicans*, *Pteris vittata*, *Osmunda regalis*, *Phyllytis scolopendrium*, thriving near waterfalls and/or on shady rocky faces located in narrow ravines and gorges, constantly dripping with clear and well oxygenated freshwater (Brullo et al. 1989), in northeastern Sicily (Tyrrhenian side of the Peloritani Mountains, no longer present on Mount Etna), within the thermo- and mesomediterranean bioclimate.

Diagnostic sentence: Bryo-pteridophytic communities with large ferns, covering rocky faces located in narrow and shady ravines and gorges within the thermo- and mesomediterranean bioclimate.

List of diagnostic species: *Woodwardia radicans*, *Adiantum capillus-veneris*, *Asplenium scolopendrium*, *Dryopteris affinis*, *Osmunda regalis*, *Pteris cretica*, *Pteris vittata*, *Struthiopteris spicant*, *Bryum pseudotriquetrum* (Hedw.) P. Gaertn., B. Mey. Scherb. *Eucladium verticillatum* (Hedw.) Bruch Schimp., *Didymodon tophaceus* (Brid.) Lisa, *Pellia endiviifolia* (Dicks.) Dumort., *Conocephalum conicum* (L.) Underw., *Palustriella commutata* (Hedw.) Ochyra, *Plagiomnium undulatum* (Hedw.) T.J. Kop., *Pellia epiphylla* (L.) Corda, *Thamnobryum alopecurum* (Hedw.) Nieuwl. ex Gangulee, *Rhizomnium punctatum* (Hedw.) T.J. Kop.

Dynamic contacts: This vegetation may come in contact with the forest communities ascribed to Habitat "9180*: *Tilio-Acerion* forests of slopes, screes and ravines", mixed mesophilic broadleaved forests growing on steep rocky slopes or gorges and with the evergreen forests dominated by holm oaks of the habitat "9350 *Quercus ilex* and *Quercus rotundifolia* forests". In areas affected by frequent fires, this habitat may come in contact with secondary woody communities such as tall shrublands dominated by *Erica arborea*.

Phytosociological arrangement: *Adianto capilli-veneris-Osmundetum regalis* Brullo, Lo Giudice Privitera 1989, *Adianto capilli-veneris-Pteridetum vittatae* Brullo, Lo Giudice Privitera 1989, *Conocephalo conici-Woodwardietum radicantis* Brullo, Lo Giudice Privitera 1989, *Thamnobryo alopecuri-Phyllitidetum scolopendrium* Brullo, Privitera Puglisi 1993 [*Polysticho setiferi-Phyllitidion scolopendrii* Ubaldi ex Ubaldi Biondi in Biondi, et al. 2014, *Adiantetalia capilli-veneris* Br.-Bl. ex Horvatić 1939, *Adiantetea capilli-veneris* Br.-Bl. in Br.-Bl., Roussine Nègre 1952].

7) Birch woodlands of Mount Etna

Motivation: The *Betula etnensis* woodlands of Mount Etna represent the most southern and isolated remnants of a vegetation which spread in Sicily during the cold phases of the Pleistocene glacial events and have locally persisted in restricted areas where the summer aridity is buffered by orographic moisture condensation, on well-drained acidic soils. The migration pattern of birch trees developed through southern France and along the Tyrrhenian side of the Apennines and Calabrian Massifs, until reaching Sicily (Agostini, 1981). Here, the isolated populations of birch gave rise to a new lineage, slightly diversified from *Betula pendula*, as a consequence of geographic isolation and adaptation to the new volcanic habitat (De Dato et al. 2020; Giusso del Galdo et al. 2021).

Owing to the biogeographical interest and the occurrence of narrow endemic species, the habitat dominated by B. etnensis deserves adequate protection.

Macrotype: 92 Mediterranean deciduous forests

Name: Birch woodlands of Mount Etna

Description: Mesophilous, edapho-xerophilous deciduous woodland physiognomically dominated by *Betula etnensis* Rafin., a narrow endemic tree species exclusively found on Mt. Etna, where it was probably more widespread in the past and has been exploited for centuries by local people, mainly for charcoal production (Strano 2010). This deciduous plant community is usually represented by open woods growing on volcanic scoriae, where the soil evolution is hampered by the severe climatic conditions and by the frequent volcanic events, such as tephra rains. This woodland type ranges between 1400 and 2000 m a.s.l., chiefly on the north-eastern slopes, showing its optimum within the upper supramediterranean hu-mid-hyperhumid bioclimatic belt, with penetrations towards the oromediterranean belt (Brullo et al. 2012). This community exhibits a remarkably pioneer character, occurring within the area potentially occupied by the beech woods of the *Epipactido meridionalis-Fagetum sylvaticae* above 1800 m a.s.l.

Diagnostic sentence: Deciduous birch woods of *Betula etnensis*, growing on volcanic scoriae, restricted to the supramediterranean vegetation belt of the north-eastern slopes of Mt. Etna.

List of diagnostic species: *Cephalanthera longifolia*, *Adenocarpus bivonae*, *Betula etnensis*. Other frequent species: *Elymus panormitanus*, *Brachypodium sylvaticum*, *Calamagrostis epigejos*, *Festuca circummediterranea*, *Vicia cassubica*, *Orobanche rapum-genistae*, *Tanacetum siculum*, *Daphne laureola*, *Rubus aetnicus*, *Juniperus hemisphaerica*, *Cytisus scoparius*, *Genista etnensis*, *Pinus nigra* subsp. *calabrica*, *Quercus congesta*, *Erysimum etnense*, *Secale strictum*, *Jasione montana*, *Silene sicula*.

Dynamic Contacts: This association comes in contact at lower altitudes with the edapho-xerophilous vegetation of *Daphno laureolae-Pinetum calabricae*, at higher altitudes with the hedgehog-heaths ascribed to *Astragaletum siculi* (Bagnato et al. 2014).

Phytosociological arrangement: *Cephalanthero longifoliae-Betuletum aetnensis* Brullo C. et al. 2012 [*Pino calabricae-Quercion congestae* Brullo, Scelsi, Siracusa Spampinato 1999, *Quercetalia pubescenti-petraeae* Klika 1933, *Quercetea pubescentis* Doing-Kraft ex Scamoni et Passarge 1959].

8) *Ostrya carpinifolia* woods of Sicily

Motivation: Sicily hosts the southwesternmost stands of Ostrya carpinifolia. This species is known for having gone through alternate phases of expansion/regression during the late Quaternary vegetation history of the Mediterranean Basin; last maximum expansion occurred between 8000 and 4500 years ago (Willis 1992; Tzedakis 1994; Denèfle et al. 2000). The current distribution of the species in Sicily is restricted to steep valley slopes scattered in the main mountain ranges of the island, where it participates to extremely localized broadleaved deciduous mesophilic woods. The high biogeographical interest and the relict connotation of these woods impose to consider them an important conservation target for preserving the Sicilian biodiversity.

Macrotype: 92 Mediterranean deciduous forests

Name: Ostrya carpinifolia woods of Sicily

Description: Three-layered thermophilous and aerohygrophilous broadleaved woods, thriving on steep valley slopes, gorges and tributary detrital fans, scattered in the main mountain ranges of Sicily on different soil parental materials, from limestone to acidic metamorphic and volcanic rocks. The canopy is dominated by thermophilous deciduous (with some evergreen) trees, among which *Ostrya carpinifolia* and sometimes *Acer obtusatum* provide the floristic and physiognomic characterization of this habitat. Under conditions of higher edaphic and environmental humidity, *Laurus nobilis* and *Tilia platyphyllos* are also frequent, whereas under greater lighting *Quercus ilex* and *Fraxinus ornus* also play an important role. These woods largely depend on moist and fresh microclimatic conditions and range between 200 and 1200 m a.s.l., with optimum within the meso- and supramediterranean humid bioclimate. This habitat is well represented in the main gorges of the Hyblaean plateau, along the eastern slope of Mount Etna and in the mountain ranges of NE-Sicily (Peloritani and Nebrodi Mts.; Brullo Marcenò 1985; Bartolo et al. 1992; Brullo et al. 1996; Minissale et al. 2007). The scattered occurrence of many isolated spots of *Ostrya carpinifolia* in the mounts near Palermo and on the Sicani Mts. (Marcenò and Ottonello 1993; Venturella et al. 1991; Marino and Ilardi 2007; Castellano et al. 2009; Giardina et al. 2015) suggests that this habitat was once more widespread also in western Sicily.

Diagnostic sentence: Thermophilous and aerohygrophilous broadleaved woods with Ostrya carpinifolia, colonizing steep valley slopes, gorges, and tributary detrital fans, within the meso- and supramediterranean humid bioclimate.

List of diagnostic species: *Ostrya carpinifolia* (dominant). Other frequent species: *Acer campestre*, *A. obtusatum* (incl. *A. obtusatum* subsp. *aetnense*), *Quercus ilex*, *Laurus nobilis*, *Fraxinus ornus*, *Quercus congesta*, *Q. virgiliana*, *Tilia platyphyllos*, *Cytisus villosus*, *Bupleurum fruticosum*, *Lonicera etrusca*, *Emerus majus*, *Athyrium filix-foemina*, *Brachypodium sylvaticum*, *Daphne laureola*, *Phyllitis scolopendrium*, *Polystichum setiferum*, *Symphytum tuberosum*, *Drymochloa drymeja*, *Thalictrum calabricum*, *Sorbus torminalis*, *Pistacia terebinthus*.

Dynamic contacts: On gently sloping sites, the *Ostrya carpinifolia* woods get in contact with the zonal forest vegetation of the surroundings, often represented by *Erico arboreae-Quercetum virgilianae*, *Sorbo torminalis-Quercetum virgilianae*, *Aceri campestris-Quercetum ilicis*, *Vicio cassubicae-Quercetum cerridis*, *Agropyro panor-*

mitani-Quercetum congestae, *Arabido turritae-Quercetum congestae*, *Doronico orientali-Quercetum ilicis*, *Teucrio siculi-Quercetum ilicis*, *Ampelodesmo mauritanici-Quercetum ilicis*. Contacts are also established with the comophytic vegetation of *Bartramio-Polypodion cambrici* and with the chasmophytic vegetation of *Tamnobryo alopecuri-Phyllitidetum scolopendrii*, which colonize the outcropping rocks within the association.

Phytosociological arrangement: *Aceri obtusati-Ostryetum carpinifoliae* Brullo Marcenò 1985, *Arabido turritae-Quercetum congestae* Brullo Marcenò 1985, *Hieracio criniti-Aceretum aetnensis* Brullo C. et al. 2012 [*Tilio-Ostryon carpinifoliae* Brullo, Scelsi Spampinato 2001, *Fagetalia sylvaticae* Pawłowski in Pawłowski et al. 1928, *Carpino-Fagetea sylvaticae* Jacuks Passarge 1968]; *Ostryo carpinifoliae-Quercetum ilicis* Lapraz 1975 [*Fraxino orni-Quercion ilicis* Biondi, Casavecchia et Gigante in Biondi et al. 2013, *Quercetalia ilicis* Br.-Bl. ex Molinier 1934, *Quercetea ilicis* Br.-Bl. ex A. Bolòs et O. de Bolos in A. Bolòs y Vayreda 1950].

Discussion

The combination of a phytosociological and phytogeographical approach to habitat recognition represents a convenient way to resolve the conundrum of habitat identification. However, some appropriate additions to the Habitat Directive would be highly desirable to ensure adequate and explicit protection to the Sicilian habitats listed above, that host rare species of phytogeographic interest, highly localized edaphic specialists and, also, historical rural landscapes shaped by traditional land uses.

Some of these habitats have been forced into comparable units already codified by Directive 92/43 (http://vnr.unipg.it/habitat/). However, an excessive "stretching" in the habitat interpretation leaves room for ambiguity and uncertainties in the correct identification and designation of the conservation targets (Pasta La Mantia 2009).

For example, the recognition of the habitat here proposed as "Meso- and supramediterranean acidophilous Sicilian broomfields" would eliminate the interpretative impasse that forces some of these formations, either, into habitat 5330 (Thermo-Mediterranean and pre-desert scrub), together with thermomediterranean broom fields (retamares) in Sicily represented by coastal formations dominated by *Retama raetam* subsp. *gussonei* or by Genista tyrrhena, or, instead, into habitat 4090 (Endemic oro-Mediterranean heaths with gorse), together with the high-mountain vegetation dominated by *Astragalus siculus* or *A. nebrodensis*.

Similarly, the recognition of the habitats here proposed as "Mud volcanoes and badlands in the evaporitic outcrops of Sicily" and "Sicilian gypsum outcrops" would allow to consider as a whole the mosaic of contiguous habitats that characterize these so peculiar geomorphological units (similarly to what happens with the Habitat 8320 "volcanic outcrops and lava fields"). This would ensure better protection also to the vegetation dominated by some endemic taxa, such as Tripolium sorrentinoi (*Asteretum sorrentini*, see Brullo et al. 2010) or *Astragalus caprinus* subsp. *huetii* (*Astragalo huetii-Ampelodesmetum mauritanici*, see Minissale 1995), currently lumped into the omni-comprehensive and ubiquitous habitat 6220 (Pseudo-steppe with grasses and annuals of the *Thero-Brachypodietea*).

The choice of using a "geology-based" criterion to circumscribe the two above-mentioned habitats is justified by the difficulty of separating the tiles of a mosaic in which vegetation units ascribed to different phytosociological classes (such as *Pegano-Salsoletea*, *Lygeo-Stipetea*, *Saginetea maritimae*, *Thero-Brachypodietea*, *Juncetea maritimi* and others) intermingle in very close spatial contiguity. The opportunity to propose as autonomous some of these vegetation units would require an in-depth comparative analysis of their physiognomic and structural characteristics, which is not always available apart few exceptions (Brullo et al. 2013; Marcenò et al. 2019) and is adventurous to pretend from an instrument, i.e. the Habitat Directive, whose main purpose is identifying conservation targets in the easiest and most practical possible way. Moreover, designating mud volcanoes and badlands as a whole habitat allows to safeguard the landscape unicum and its root causes, which are eminently geological, and to ensure an unitary impact assessment to any project of "hydraulic-forestry amelioration" with acacias or eucalyptuses or, worst, to any transformation of these sites into landfills, photovoltaic power plants, go-cart tracks and, in the case of gypsum outcrops, also into intensive vineyards after gypsum-grinding.

The habitat "mud volcanoes and badlands in the evaporitic outcrops of Sicily" is akin to the habitat already proposed (Genovesi et al. 2014) as "halophilous and/or subalophilous pioneer vegetation in badlands". However, the badlands of Peninsular Italy host a somewhat different vegetation from that of Sicily, as it lacks the shrub component typical of the *Pegano-Salsoletea* class. Therefore, it was decided to propose a new habitat for Sicily.

Also, the habitat "*Ostrya carpinifolia* woods of Sicily" is similar the habitat already proposed (Genovesi et al. 2014) as "hop-hornbeam Italo-Balkan woods". However, the latter has a floristic composition and ecological settings quite different from those in Sicily and, with reference to the EUNIS habitat classification, it is to be classified among the "temperate and submediterranean thermophilous deciduous forest" (code: G1.7a) rather than the "Mediterranean thermophilous deciduous forest" (code: G1.7b), as it happens for the Sicilian stands.

Lastly, the habitat "Shady dripping cliffs with Woodwardia radicans and other large ferns" is similar to the habitat "Mediterranean dripping cliffs", also present in Sicily and already proposed (Spampinato and Puglisi 2009; Genovesi et al. 2014) to be integrated into the Habitats Directive. However, it is considered appropriate to treat as a separate habitat the *Adiantetea* vegetation characterized by the presence of large ferns (such as *Woodwardia radi-*

cans and *Pteris vittata*) which, due to their extreme rarity, should be pertaining to priority habitat.

To fully understand the obvious gaps of the Habitat Directive in Sicily, it is worth to consider that the Italian botanists did not play a very active role in the definition of the "Annexes" to the Directive, both as regards species and habitats (Biondi et al. 2010). This lack particularly affects the surface areas of the Italian territory belonging to the Mediterranean ecoregion, determining a gap that could not be filled until today. In fact, since the publication of the Habitat Directive, no official integration of its annexes has been allowed, with exceptions reserved only to the countries involved in the EU enlargement.

In recent years, the regional administration of Sicily has put significant effort to ensure the long-term management of the Natura 2000 sites, taking account of all potential sources of EU, national and regional funding. These efforts include the implementation of management plans, the recognition of new sites (Fig. 1) and the establishment of a list of priority actions to be carried out in the next decade. Unfortunately, these efforts are not sufficient to ensure adequate protection to many relevant habitats and species occurring in Sicily, due to the above-mentioned shortcomings of the Habitat Directive and to some inconsistencies in the designation of the habitats already included in the same Directive (Pasta La Mantia 2009).

As it happens for many habitats officially designated as conservation targets, also the "neglected" habitats mentioned in this contribution are declining both in extent and quality for different reasons, related to land abandonment, land-use change, destruction and alteration of the local biota, pollution and eutrophication of water, wetland reclamation, water abstraction, introduction of alien species, urbanisation and infrastructure development. These pressures and threats act at different spatio-temporal scales and vary across different habitat types (Bagella et al. 2016; Gigante et al. 2016, 2018; Angiolini et al. 2017; Guarino et al. 2021). In particular, the disappearance or the exacerbation of anthropogenic disturbance (e.g., abandonment of traditional practices, cessation of grazing or, instead, overgrazing and increased fires frequency) can compromise many of the habitats we have proposed.

Conclusions

Aim of every protected area in the world is to promote in situ conservation strategies for threatened habitats and species. This should be done by the set up of a network of stakeholders, administrators and scientific experts which will support capacity building, management and policy actions. Unfortunately, these intentions are inevitably constrained by the lack of scientific knowledge on the ecosystem functioning and by the reality of limited economical resources. Conservation must therefore be based on the establishment of priorities, in order to determine how these limited resources could be best allocated (Guarino et al. 2011).

People's perception of protected areas is, in most of the cases, limited to the recreational or aesthetical function of biotopes and biodiversity: a kind of "playground for ecologists" that can be used for outdoor activities and experiential marketing. This limited view should be widened through the use of protected areas as living labs for the environmental education, to raise the public awareness on the function of ecosystems. Unfortunately, managers and planners seem to be much more sensitive to the marketing and promotion of typical products and to the construction of infrastructure to improve accessibility and usability of these areas. This is not necessarily a negative aspect, but it can be so if it becomes the priority target for the development of protected areas (Guarino 2021). Too many habitats and natural sceneries have been irreparably spoiled by senseless interventions to "improve" accessibility and usability. This is the case, for example, of the renowned Etnean "Rifugio Sapienza" and surrounding areas, where thousands of absent-mindedly tourists are brought on Mt. Etna "to walk on the lava", with best regards to the superficiality that already characterizes the average way of living of the urban people.

The only way to contrast these dangerous shortcuts is a correct and unambiguous designation of the conservation targets, accompanied by appropriate conservation measures, management plans, prioritized action framework, monitoring and periodical updating of the Habitat Directive in the light of the new achievements emerging from territorial research and thematic in-depth studies. Last but not least, substantial resources have to be invested in education and dissemination campaigns, in order to reach a societal consensus on the need for conservation of the Natura 2000 sites and the Sicilian biodiversity in general.

Bibliography

Agostini R (1981) Contributo alla conoscenza della distribuzione della betulla (*Betula pendula* Roth) nell'Appennino centro-meridionale e in Sicilia e del suo significato fitogeografico. Studi Trentini di Scienze Naturali 58: 35–56.

Angelini P, Chiarucci A, Nascimbene J, Cerabolini BE, Dalle Fratte M, Casella L (2018) Plant assemblages and conservation status of habitats of Community interest (Directive 92/43/EEC): definitions and concepts. Ecological Questions 29: 87–97.

Angiolini C, Viciani D, Bonari G, Lastrucci L (2017) Habitat conservation prioritization: a floristic approach applied to a Mediterranean wetland network. Plant Biosystems 151(4): 598–612. https://doi.org/10.1080/11263504.2016.1187678

Attorre F, Pignatti S, Spada F, Casella L. Agrillo E (2018) Introduction: Vegetation science and the habitats directive: approaches and methodologies of a never-ending story. Rendiconti Lincei 29: 233–235. https://doi.org/10.1007/s12210-018-0716-5

Bagella S, Gascón S, Filigheddu R, Cogoni A, Boix D (2016) Mediterranean Temporary Ponds: new challenges from a neglected habitat. Hydrobiologia 782(1): 1–10. https://doi.org/10.1007/s10750-016-2962-9

Bagnato S, La Piana V, Mercurio R, Merlino A, Scarfò F, Sciascia N, Solano F, Spampinato G (2014) Dinamiche evolutive in boschi cedui di betulla (*Betula aetnensis* Rafin.) nel Monte Etna (Sicilia). Forest@ 11: 52–64. https://doi.org/10.3832/efor1191-011

Barbera G, Cullotta S, Rossi-Doria I, Rühl J. Marino E. (2009) Inventario dei paesaggi a terrazze in Sicilia. ARPA Sicilia, Palermo, Italy. https://doi.org/10.4129/CNS2008.227

Bartolo G, Brullo S, Minissale P, Spampinato G (1992) Contributo alla conoscenza dei boschi a *Quercus ilex* della Sicilia. Acta Bot. Malac 15 [1990]: 203-215. https://doi.org/10.24310/abm.v15i.9303

Bartolo G, Brullo S, Pulvirenti S (1994) Su una nuova associazione della classe Cytisetea striato-scoparii in Sicilia. Bollettino dell'Accademia Gioenia di Scienze Naturali 27(346): 399–407.

Baumel A, Mirleau P, Viruel J, Bou Dagher Kharrat M, La Malfa S, Ouahmane L, Diadema K, Moakhar M, Sanguin H, Médail F (2018) Assessment of plant species diversity associated with the carob tree (Ceratonia siliqua, Fabaceae) at the Mediterranean scales. Plant Ecology and Evolution 151(2):185–193. https://doi.org/10.5091/plecevo.2018.1423

Bazan G, Marino P, Guarino R, Domina G, Schicchi R (2015) Bioclimatology and vegetation series in Sicily: a geostatistical approach. Annales Botanici Fennici 52: 1–18. https://doi.org/10.5735/085.052.0202

Bazan G, Ilardi V, Minissale P, Sciandrello S (2006) La biodiversità vegetale di Monte Gibliscemi Mazzarino Sicilia. Quaderni di Botanica Ambientale e Applicata 172: 121–140.

Bianca G (1881) Il carrubo. Monografia storico-botanico-agraria da servire di appendice alla monografia agraria del territorio d'Avola in Sicilia. Firenze, Tip. M. Ricci.

Biondi E, Blasi C, Burrascano S, Casavecchia S, Copiz R, Del Vico E, Galdenzi D, Gigante D, Lasen C, Spampinato G, Venanzoni R, Zivkovic L (2010) Manuale italiano di interpretazione degli habitat (Direttiva 92/43/CEE). MATTM, Roma.

Blondet M, Koning J, Borrass L, Ferranti F, Geitzenauer M, Weiss G, Turnhout E, Winkel G (2017) Participation in the implementation of Natura 2000: A comparative study of six EU member states. Land Use Policy 66: 346–355. https://doi.org/10.1016/j.landusepol.2017.04.004

Braun-Blanquet J (1964) Pflanzensoziologie. Grundzüge der Vegetationskunde. 3 Auflage, Springer Verlag, Wien New York, 330 pp. https://doi.org/10.1007/978-3-7091-8110-2

Boratyński A, Browicz K, Zieliński J (1992) Chorology of trees and shrubs in Greece. Poznań, Polish Academy of Sciences; Kornik, Institute of Dendrology, 848 pp.

Browicz K, Zieliński J (1984) Chorology of trees and shrubs in South-West Asia and Adjacent Regions. Vol. 1. Institute of Dendrology, Polish Academy of Sciences, Warszawa Poznań, 172 pp.

Brullo C, Brullo S, Giusso del Galdo G, Guarino R, Minissale P, Scuderi L, Siracusa G, Sciandrello S, Spampinato G. (2010) The *Lygeo-Stipetea* class in Sicily. Annali di Botanica (4)0: 57–84.

Brullo C, Brullo S, Giusso Del Galdo G, Guarino R, Siracusa G, Sciandrello S. (2012) The *Querco-Fagetea sylvaticae* class in Sicily: an example of boreal-temperate vegetation in the central Mediterranean Region. Annali di Botanica (4)2: 19–38.

Brullo S, Giusso del Galdo G, Guarino R, Minissale P, Sciandrello S, Spampinato G (2013) Syntaxonomic survey of the class *Pegano harmalae-Salsoletea vermiculatae* Br.-Bl. O. Bolòs 1958 in Italy. Plant Biosystems 147(2): 472–492. https://doi.org/10.1080/11263504.2012.717544

Brullo S, Gianguzzi L, La Mantia A. Siracusa G (2009) La classe *Quercetea ilicis* in Sicilia. Bollettino dell'Accademia Gioenia di Scienze naturali 41(369): 1–77.

Brullo S, Guarino R, Ronsisvalle GA (2000) La vegetazione del litorale di Manfria, presso Gela (Sicilia), area soggetta a vincolo archeologico. Archivio Geobotanico 4(1) (1998): 91–107.

Brullo S, Lo Giudice R and Privitera M (1989) La classe *Adiantetea* in Sicilia. Archivio Botanico Italiano, 65(1-2): 81–99.

Brullo S, Marcenò C (1979) Dianthion rupicolae nouvelle alliance sud-tyrrhénienne des *Asplenietalia glandulosi*. Documents Phytosociologiques n.s. 4: 131–146.

Brullo S, Marcenò C (1985) Contributo alla conoscenza della classe *Quercetea ilicis* in Sicilia. Notiziario Fitosociologico 10(1): 183–229.

Brullo S, Minissale P, Signorello P, Spampinato G (1996) Contributo alla conoscenza della vegetazione forestale della Sicilia. Colloques Phytosociologiques 24 (1995): 635–647.

Cangemi M, Madonia P (2014) Mud volcanoes in onshore Sicily: a short overview. In: Wiese F, Reich M, Arp G (eds.), "Spongy, slimy, cosy more…", Commemorative volume in celebration of the 60th birthday of Joachim Reitner. Goettingen Contributions to Geosciences 77: 123–127.

Castellano G, Raimondo F. M, Schicchi R (2009) Aspetti di vegetazione a leccio e carpino nero nei Monti Sicani (Sicilia centro-occidentale). In: Di Marzio P et al. (ed), 104° Congresso della Società Botanica Italiana "Le scienze botaniche nella cultura e sviluppo economico del territorio", Riassunti delle Comunicazioni e dei Poster (Campobasso, 16-19 settembre 2009): 289.

Chytrý M, Tichý L, Hennekens SM, Knollová I, Janssen JA, Rodwell JS (...) Hájek M (2020) EUNIS Habitat Classification: expert system, characteristic species combinations and distribution maps of European habitats. Applied Vegetation Science 23(4): 646–675. https://doi.org/10.1111/avsc.12519

Conti F, Manzi A and Pedrotti F (1992) Libro rosso delle piante d'Italia. WWF Italia, Società Botanica Italiana. TIPAR Poligrafica Editrice, Camerino, 139 pp.

Conti F, Manzi A and Pedrotti F (1997) Liste Rosse Regionali delle Piante d'Italia. WWF Italia, Società Botanica Italiana. TIPAR Poligrafica Editrice, Camerino, 139 pp.

Crisafulli A (2007) Aspetti ecofisiologici e biogeografici delle comunità vegetali relitte a Woodwardia radicans (L.) Sm. PhD thesis, University of Messina, XIX cycle.

Crisafulli A, Picone RM, Spampinato G (2021) *Woodwardia radicans* in Sicilia: distribuzione, ecologia e stato di conservazione. Notiziario della Società Botanica Italiana 5: 14–16.

Christenhusz M, Bento Elias R, Dyer R, Ivanenko Y, Rouhan G, Rumsey F and Väre H (2017) Woodwardia radicans. The IUCN Red List of Threatened Species 2017: e.T162393A85426487.

D'Amato A (2018) L'uomo e l'albero di carrubo. Un esempio di convivenza transculturale. Istituto Euro-Arabo. https://www.printfriendly.com/p/g/JgUksm

De Beaulieu JL, Miras Y, Andrieu-Ponel V, Guiter F (2005) Vegetation dynamics in north-western Mediterranean regions: Instability of the Mediterranean bioclimate. Plant Biosystems 139(2): 114–126. https://doi.org/10.1080/11263500500197858

De Bélair G (2010) Woodwardia radicans. The IUCN Red List of Threatened Species 2010: e.T162393A5585162.

De Dato GD, Teani A, Mattioni C, Aravanopoulos F, Avramidou EV, Stojnic S, Ganopoulos I, Belletti P, Ducci F (2020) Genetic analysis

by nuSSR markers of Silver Birch (*Betula pendula* Roth) populations in their southern European distribution range. Frontiers in Plant Science 11: 310. https://doi.org/10.3389/fpls.2020.00310

Denèfle, M, Lézine, A, Fouache, E, Dufaure J (2000) A 12,000-Year Pollen Record from Lake Maliq, Albania. Quaternary Research 54(3): 423–432. https://doi.org/10.1006/qres.2000.2179

Ente Fauna Siciliana (2003) La via del Carrubo: passato, presente e futuro d'una pianta del Mediterraneo. Ente Fauna Siciliana, Collana "Sicilia Naturalistica" n° 1, 63 pp.

Escudero PS, Palacio S, Maestre F, Luzuriaga A (2015) Plant life on gypsum: a review of its multiple facets. Biological Reviews 90: 1-18. https://doi.org/10.1111/brv.12092

Evans D (2012) Building the European Union's Natura 2000 network. Nature Conservation 1: 11–26. https://doi.org/10.3897/natureconservation.1.1808

Genovesi P, Angelini P, Bianchi E, Dupré E, Ercole S, Giacanelli V, Ronchi F, Stoch F (2014). Specie e habitat di interesse comunitario in Italia: distribuzione, stato di conservazione e trend. ISPRA, Serie Rapporti, 194/2014.

Gianguzzi L (1999) Flora e vegetazione dei Nebrodi. Itinerari didattici. Regione Siciliana, Sezioni Operative per l'Assistenza Tecnica nn° 5, 7, 8,10, 11, Sant'Agata di Militello (ME), 232 pp.

Gianguzzi L, Cusimano D, Romano S (2014) Phytosociological characterization of the *Celtis tournefortii* subsp. *aetnensis* microwoods in Sicily. Plant Sociology 51(2): 17–28 .

Gianguzzi L, Papini F, Cusimano D (2016) Phytosociological survey vegetation map of Sicily (Mediterranean region). Journal of Maps 12(5): 845–851. https://doi.org/10.1080/17445647.2015.1094969

Giardina G, La Mantia T, Sala G, Pasta S (2015) *Ostrya carpinifolia* Scop. (*Betulaceae*) a Ficuzza (Monti Sicani, Provincia di Palermo): note ecologiche e demografiche. Naturalista Siciliano ser. 4 39(1): 73–75.

Gigante D, Foggi B, Venanzoni R, Viciani D, Buffa G (2016) Habitats on the grid: the spatial dimension does matter for redlisting. Journal of Nature Conservation 32: 1–9. https://doi.org/10.1016/j.jnc.2016.03.007

Gigante D, Acosta ATR, Agrillo E. et al. (2018) Habitat conservation in Italy: the state of the art in the light of the first European Red List of Terrestrial and Freshwater Habitats. Rendiconti Lincei 29: 251–265. https://doi.org/10.1007/s12210-018-0688-5

Giusso del Galdo G, Ranno V, Siracusa G, Brullo S (2021) Considerazioni sulla sistematica di *Betula etnensis* (*Betulaceae*), specie critica della flora sicula. Notiziario Società Botanica Italiana 5(2): 25–26.

Guarino R (1998) La vegetazione dei Monti Peloritani (Sicilia nord-orientale). Tesi di Dottorato in Scienze Ambientali I 'Fitogeografia dei Territori Mediterranei' (X Ciclo), Università degli Studi di Catania, Catania, 301 pp.

Guarino R (2021) L'Oasi di Slander. Natura Montagna 2-2020: 17–20.

Guarino R, Pasta S (2017) Botanical excursions in central and western Sicily. Field Guide for the 60th IAVS Symposium (Palermo, June 20–24, 2017). Palermo University Press, Palermo, 604 pp.

Guarino R, Chytrý M, Attorre F, Landucci F, Marcenò C. (2021) Alien plant invasions in Mediterranean habitats: an assessment for Sicily. Biological Invasions 23: 3091-3107. https://doi.org/10.1007/s10530-021-02561-0

Guarino R, Cusimano D, Ilardi V. Pasta S (2017). Syntaxonomic list of the vegetation units. In: Guarino R, Pasta S (eds.). Botanical excursions in central and western Sicily. Field Guide for the 60th IAVS Symposium (Palermo, June 20-24, 2017). Palermo University Press, Palermo, 281-370. https://doi.org/10.21570/BUL-201712-1

Guarino R, Guglielmo A (eds.) (2010) Il litorale di Manfria (Gela), natura e storia da proteggere. Edibo, Catania, 127 pp.

Kirk DA, Park AC, Smith AC, Howes BJ, Prouse BK, Kyssa NG, Fairhurst EN, Prior KA (2018) Our use, misuse, and abandonment of a concept: Whither habitat? Ecology and Evolution 8: 4197–4208. https://doi.org/10.1002/ece3.3812

Linnell, J.D, P. Kaczensky, U. Wotschikowsky, N. Lescureux L. Boitani 2015. Framing the relationship between people and nature in the context of European conservation. Conservation Biology 29: 978–85. https://doi.org/10.1111/cobi.12534

Loidi J, Ortega M, Orrantia O (2007) Vegetation science and the implementation of the habitat directive in Spain: up-to-now experiences and further development to provide tools for management. Fitosociologia 44(2, suppl. 1): 9–16.

Manolaki P, Vogiatzakis IN (2017) Ecosystem services in a peri-urban protected area in Cyprus: a rapid appraisal. Nature Conservation 22: 129–146. https://doi.org/10.3897/natureconservation.22.13840

Marcenò C, Guarino R, Mucina L, Biurrún I, Deil U, Shaltout K, Finckh M, Font X, Loidi J (2019) A formal classification of the *Lygeum spartum* vegetation of the Mediterranean Region. Applied Vegetation Science 22: 593–608. https://doi.org/10.1111/avsc.12456

Marcenò C, Ottonello D (1993) Osservazioni fitosociologiche su alcune leccete dei Monti di Palermo (con appendice floristica). Atti Accademia Scienze Lettere e Arti Palermo, ser. 5, 11, P. I. (Sci.) (1990-91): 121–143.

Marino P, Ilardi V (2007) Sulla presenza di *Ostrya carpinifolia* (*Corylaceae*) nei substrati della serie evaporitica (Sicilia centrale). In: Raimondo FM, Venturella G (eds.), Riassunti: Relazioni - Comunicazioni - Poster del 102° Congresso Nazionale della Società Botanica Italiana (Palermo, 26-29 settembre 2007), Collana Sicilia Foreste 34: 305.

Mikhaylov, AS, Mikhaylova AA, Kuznetsova TY (2018) Coastalization effect and spatial divergence: Segregation of European regions. Ocean Coastal Management 161: 57–65. https://doi.org/10.1016/j.ocecoaman.2018.04.024

Minissale P (1995) Studio fitosociologico delle praterie ad *Ampelodesmos mauritanicus* della Sicilia. Colloques Phytosociologiques 21(1993): 615–652.

Minissale P, Sciandrello S, Spampinato G (2007) Analisi della biodiversità vegetale e relativa cartografia della Riserva Naturale Orientata "Pantalica, Valle dell'Anapo e Torrente Cava Grande" (Sicilia sud-orientale). Quaderni di Botanica Ambientale e Applicata 18: 145–207.

Montelucci G (1972) Considerazioni sulla componente orientale nelle foreste della Penisola. Annali dell'Accademia Italiana di Scienze Forestali 21: 121–212.

Morrison ML, Mathewson HA (2015) Wildlife habitat conservation: Concepts, challenges, and solutions. John Hopkins University, Baltimore MD, 200 pp.

Mucina L, Bültmann H, Dierßen K, Theurillat J.-P, Raus T, Čarni A, et al. (2016) Vegetation of Europe: hierarchical floristic classification system of vascular plant, bryophyte, lichen, and algal communities. Applied Vegetation Science 19: 3–264. https://doi.org/10.1111/avsc.12257

Musarella CM, Mendoza-Fernández AJ, Mota JF, Alessandrini A, Bacchetta G, Brullo S, et al. (2018) Checklist of gypsophilous vascular flora in Italy. PhytoKeys 63: 61–82. https://doi.org/10.3897/phytokeys.103.25690

Orombelli G, Ravazzi C (1996) The Late Glacial and Early Holocene chronology and paleoclimate. Il Quaternario 9(2): 439–444.

Pasta S (2001) Recenti acquisizioni floristico-vegetazionali sull'area delle Macalube di Aragona. Naturalista Siciliano, s. 4 25(suppl.): 155–196.

Pasta S, Guarino R (2017) Chapter V. Evaporitic memories. In: Guarino R, Pasta S (eds.), Botanical Excursions in Central and Western Sicily. Field Guide for the 60th IAVS Symposium (Palermo, 20–24 June 2017). Palermo, Palermo University Press: 117–142. https://doi.org/10.21570/BUL-201712-1

Pasta S, La Mantia T (2009) La Direttiva 92/43/CEE ed il patrimonio agro-forestale, pre-forestale e forestale siciliano: alcune note critiche. Naturalista Siciliano, s. 4 33(3–4): 315–328.

Pasta S, Garfì G, Carimi F, Marcenò C (2017) Human disturbance, habitat degradation and niche shift: The case of the endemic Calendula maritima Guss. (W Sicily, Italy). Rendiconti Lincei 28: 415–424. https://doi.org/10.1007/s12210-017-0611-5

Pezzetta A (2010) Gli elementi orientali appenino-balcanici, illirici, pontici e sud-est europei della flora italiana: origini e distribuzione regionale. Annales, ser. Hist. Nat. 20(1): 75–88 + i-xiv (App.).

Pignatti S, Guarino R, La Rosa M (2017-2019). Flora d'Italia, 2nd edition. Edagricole, Edizioni Agricole di New Business Media, Bologna.

Puglisi M, Campisi P, Privitera M, Spampinato G (2020) Bryophyte diversity in the gypsum outcrops of Sicily (Italy). Nova Hedwigia 111: 337–355. https://doi.org/10.1127/nova_hedwigia/2020/0602

Ramón-Laca L, Mabberley DJ (2004) The ecological status of the carob-tree (*Ceratonia siliqua*, *Leguminosae*) in the Mediterranean. Botanical Journal of the Linnean Society 144: 431–436. https://doi.org/10.1111/j.1095-8339.2003.00254.x

Rossi G, Montagnani C, Gargano D, Peruzzi L, Abeli T, Ravera S, Cogoni A, Fenu G, Magrini S, Gennai M, Foggi B, Wagenspmmer R.P, Venturella G, Blasi C, Raimondo FM, Orsenigo S (eds, 2013) Lista Rossa della Flora Italiana 1. Policy species e altre specie minacciate. Roma, Comitato italiano IUCN e Ministero dell'Ambiente e della Tutela del Territorio e del Mare.

Ruffo S, Stoch F (eds) (2005) Checklist e distribuzione della fauna italiana. Memorie del Museo Civico di Storia Naturale di Verona, 2a serie, Sezione Scienze della Vita 16.

Schicchi R, Marino P (2011) Taxa relitti della flora forestale siciliana e problemi di conservazione. Biogeografia n.s. 30: 141–150. https://doi.org/10.21426/B630110595

Scoppola A and Spampinato G (eds, 2005) Atlante delle specie a rischio di estinzione. Versione 1.0. CD-Rom enclosed to the volume: Scoppola A, Blasi C (eds). Stato delle conoscenze sulla flora vascolare d'Italia. Palombi Editori. Roma.

Sciandrello S, Cambria S, Giusso Del Galdo G, Guarino R, Minissale P, Pasta S, Cristaudo A (2021) Floristic and vegetation changes on a small Mediterranean Island over the last century. Plants 10(4): 680. https://doi.org/10.3390/plants10040680

Sciandrello S, Guarino R, Minissale P, Spampinato G (2015) The endemic vascular flora of Peloritani Mountains (NE Sicily): Plant functional traits and phytogeographical relationships in the most isolated and fragmentary micro- plate of the Alpine orogeny. Plant Biosystems 149(5): 838–854. https://doi.org/10.1080/11263504.2014.908978

Siracusa G (1997) Flora e vegetazione dell'Etna. Tesi di Dottorato in Scienze Ambientali I 'Fitogeografia dei Territori Mediterranei' (VIII Ciclo), Università degli Studi di Catania, Catania, 360 pp.

Spampinato G, Cameriere P, Crisafulli A, Gangale C, Picone RM, Santangelo A, Uzunov D (2008) "*Woodwardia radicans* (L.) Sm." In: Rossi G, Gentili R, Abeli T, Gargano D, Foggi B, Raimondo FM, Blasi C (eds), Flora da conservare: implementazione delle categorie e criteri I.U.C.N. (2001) per la redazione di Nuove Liste Rosse. Inform. Bot. Ital. 40 (suppl. 1): 132–134.

Spampinato G, Puglisi M (2009) 7250 New: Rupi stillicidiose mediterranee. In: Biondi E, et al. (eds) Manuale Italiano di Interpretazione degli habitat di Direttiva 92/43/CEE. http://vnr.unipg.it/habitat/cerca.do?formato=stampaidSegnalazione=83

Strano F (2010) Betula aetnensis Raf. nel Parco Naturale dell'Etna: analisi vegetazionale ed ecologica. Tesi di Dottorato di Ricerca in Biologia ed Ecologia Vegetale in Ambiente Mediterraneo (XXIII Ciclo), Università degli Studi di Catania, 135 pp.

Tomaselli R (1972) Aspects de la végétation de l'Italie méridionale et de la Sicile et leurs relations avec la végétation des Balkans et des pays afro-asiatiques. Studi trentini Scienze Naturali sez. B 49(1): 102–118.

Tomaselli V, Adamo M, Veronico G, Sciandrello S, Tarantino C, Dimopoulos P, Medagli P, Nagendra H, Blonda P (2016) Definition and application of expert knowledge on vegetation pattern, phenology, and seasonality for habitat mapping, as exemplified in a Mediterranean coastal site. Plant Biosystems 151(5): 887–899. https://doi.org/10.1080/11263504.2016.1231143

Troia A (1997) Taxonomic and eco-geographical notes on *Celtis tournefortii* Lam. (*Ulmaceae*, *Celtidoideae*) in Sicily. Naturalista Siciliano s. 4 21(1–2): 83–92.

Tutin TG (1991) 3. *Celtis* L. In: Tutin TG, Burges NA, Chater AO, Edmondson JR, Heywood VH, Moore DM, Valentine DH, Walters SM, Webb DA (eds, 1991) Flora Europaea, vol. 1 (2nd edition): 77. Cambridge University Press, Cambridge, London, New York, Melbourne.

Tsiafouli MA, Apostolopoulou E, Mazaris AD, Kallimanis AS, Drakou EG, Pantis JD (2013) Human Activities in Natura 2000 Sites: a highly diversified conservation network. Environmental Management 51: 1025–1033. https://doi.org/10.1007/s00267-013-0036-6

Tzedakis PC (1994) Vegetation change through glacial-interglacial cycles: a long pollen sequence perspective. Philosophical Transactions of the Royal Society of London, Series B (Biological Sciences), 345: 403-432. https://doi.org/10.1098/rstb.1994.0118

Venturella G, Mazzola P, Raimondo FM (1991) Aspetti distributivi e sinecologici di Ostrya carpinifolia Scop. in Sicilia. Quaderni di Botanica Ambientale e Applicata 1 [1990]: 211–246.

Viruel J, Le Galliot N, Pironon S, Nieto-Feliner G, Suc JP, Lakhal-Mirleau F, Juin M, Selva M, Bou Dagher Kharrat M, Ouahmane L, La Malfa S, Diadema K, Sanguin H, Médail F, Baumel A (2020) A strong east-west Mediterranean divergence supports a new phylogeographic history of the carob tree (*Ceratonia siliqua*, *Leguminosae*) and multiple domestications from native populations. Journal of Biogeography 47(2): 460–471. https://doi.org/10.1111/jbi.13726

Westhoff V, van der Mareel E (1978) The Braun Blanquet approach. In: Whittaker RH (ed) Classification of Plant Communities: 287–399, 2nd ed. Junk, The Hague, The Netherlands. https://doi.org/10.1007/978-94-009-9183-5_9

Willis KJ (1992) The Late Quaternary vegetational history of north west Greece. New Phytologist 121: 139–155. https://doi.org/10.1111/j.1469-8137.1992.tb01099.x